DELHI TECHNOLOGICAL UNIVERSITY

Department of Electrical Engineering

POWER TRANSMISSION IN DELHI METRO

By:

Angad Singh Nagi (2K18/EE/026)

INDEX

INTRODUCTION

HISTORY OF POWER TRANSMISSION IN DELHI METRO

Transmission Network of Delhi Transco Limited

Existing Transmission Network

The existing network of DTL consists of a 400 kV ring around the periphery of Delhi interlinked with the 220 kV network spread all over the city. There are 4, 400 kV, and 39, 200 kV substations in Delhi. The transmission capacity of 400 kV substation is 5410 kV and 12820 kV for 200 kV substation. The length of the 400 kV line is 249 km and the length of the 200 kV line is 622.43 km overhead and 203.04 km underground

List of Substations

220 kV Substations			400 kV Substations	
220 kV (AIS) Substations	**220 kV In Progress Substations**	**220 kV Gas Insulated (GIS) Substations**	**400 kV (AIS) Substations**	**400 kV Gas Insulated (GIS) Substations**
Narela, Rohini-I, Najafgarh, Sarita Vihar	SGTN, Budhella	DIAL, Electric Lane, Kashmere Gate, Lodhi Road	Bawana	Harsh Vihar
Mehrauli, Vasant Kunj, Pappankalan-I , Rajghat		Maharani Bagh, Park Street, Peeragarhi, RK Puram	Tikri Kalan (Mundka)	
Geeta Colony, Pragati, IP Estate, Gazipur		Preet Vihar, Ridge Valley, Subzi Mandi, AIIMS	Bamnauli	
Rohini-II, Patparganj, South of Wazirabad		Wazirpur, Tughlaqabad		
Okhla, Naraina, DSIDC Bawana, Gopalpur, BTPS				
Pappankalan-II, Shalimar Bagh, Kanjhwala, PPK-III				

Power Arrangements of Delhi

DTL had been arranging power from various sources for all the five distribution licensees since 1 July 2002. Keeping in mind the Commonwealth Games 2010 it had signed power purchase agreement for more than 9000 MW of power. This arrangement continued till 31 March 2007. From 1 April 2007 onwards all the distribution agencies are directly purchasing power and all the long and short term Power Purchase Agreements have been transferred to these agencies by Delhi Electricity Regulatory Commission (DERC) on the basis of their consumption. Now it is the responsibility of the distribution companies to arrange power for their respective areas. However, a Power Procurement Group has been formed to coordinate the procurement and sale of power which is headed by a DTL Officer. Now DTL is responsible only for efficient transmission of power.

Power Generating Stations

There are total four Power Plants of Delhi Government Owned Indraprastha Power Generation Company Limited Details are as under.

There is one Central Sector Power Generation Plant owned by NTPC at Badarpur.

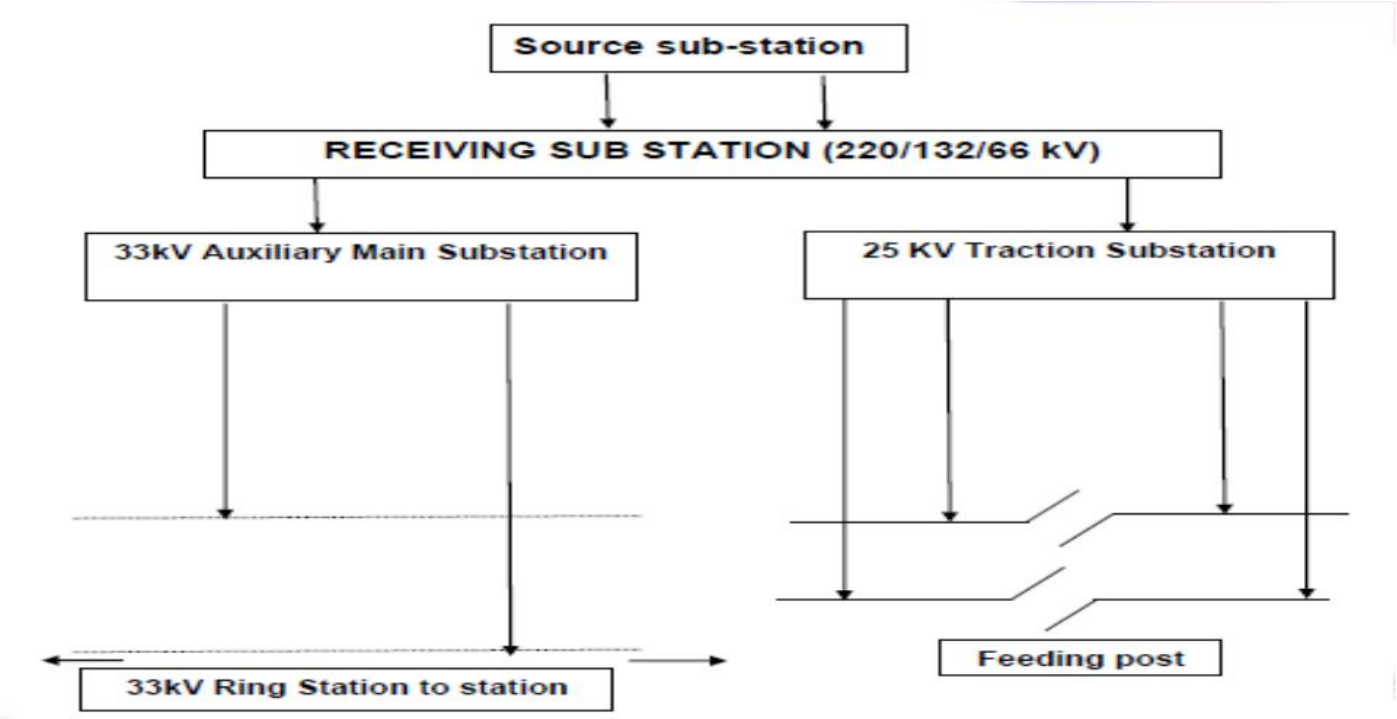
Station	**Rajghat Power Station**	**Gas Turbine Power Station**	**Pragati Power Station**	**NTPC Badarpur**
Generation Sector	**State**	**State**	**State**	**Central**
Station Capacity	135 MW	270 MW	330 MW (Total 994.5 MW)	720 MW (Derated 705 MW)
Units Size **60 MW**	2x67.5 MW	6x30 MW (GT) 3x30 MW (WHRU)	2x104 MW (GT) 1x122 MW (WHRU)	3X95 MW 2X210 MW
Year of Commissioning	1989-90	1986 & 1996	2002 -03	Unit I- 95 MW - July 1973 Unit II- 95 MW August 1974 Unit III- 95 MW March 1975 Unit IV - 210 MW December 1978 Unit V - 210 MW - December 1981
Coal Fields/Gas	NCL, BINA	GAIL HBJ Pipeline	GAIL HBJ Pipeline	Jharia Coal Fields
Water Sources	River Yamuna	River Yamuna	Treated water from Sen Nursing Home and Delhi Gate Sewage Treatment Plants	Agra Canal
Beneficiary Areas	Central & North Delhi	NDMC-VVIP, DMRC	NDMC, South Delhi	Delhi

Abbreviations: **WHRU** - Waste Heat Recovery Unit, **GT** - Gas Turbine

POWER SYSTEM ARCHITECTURE

The entire power supply system architecture is designed in such a manner that in case of power failure from one source, power can be fed from the other source.

SCHEMATIC ARRANGEMENT OF POWER SYSTEM IN DMRC:



The Internal Distribution System of Metro have their own internal HVAC cable distribution network – generally at 220kV/132kV/66kV. The purpose of such cable distribution network is to feed all auxiliary substations at each station as well as feed traction substations in case of dc traction system.

At the receiving end, there are three substations namely:

(i) Receiving Substation (RSS)

(ii) Traction Substation (TSS)

(iii) Auxiliary Main substation (AMS)

Voltage levels in DMRC:

For Receiving Substation (RSS): 220kV/132kV/66 kV AC

For Traction Substation (TSS): 25 kV AC

For Auxiliary Main Substation (AMS): 33 kV AC

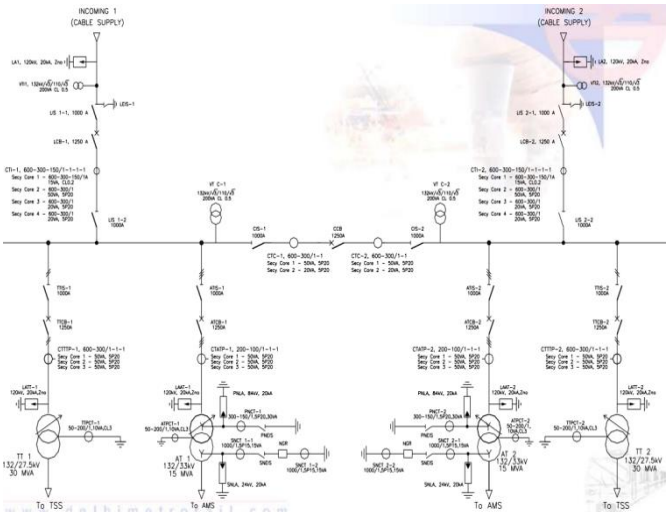
For Metro Station utilisation: 415 V AC

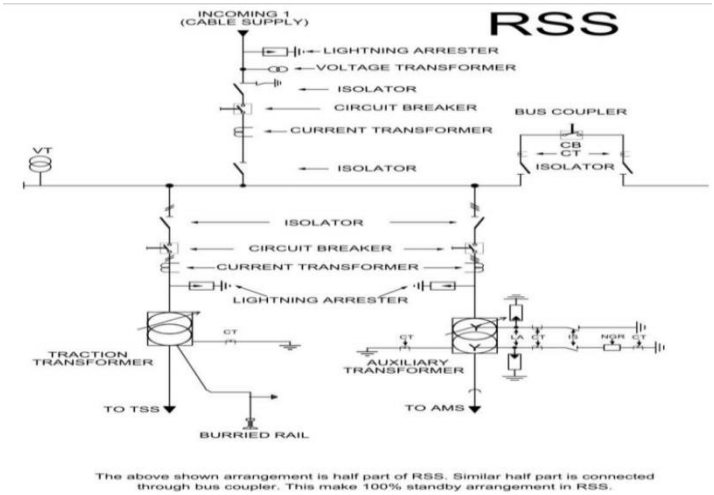
CASE STUDY

RECEIVING SUBSTATION (RSS)

Since RSS contains most of the major equipment of substation at the receiving end, the whole substation at the receiving end is generally called Receiving Substation (RSS).

SINGLE LINE DIAGRAM FOR RSS WITH 220kV or 132kV or 66kV INPUT SUPPLY:



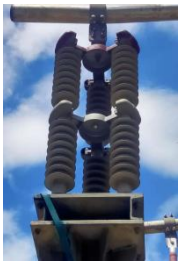


The above shown arrangement is half part of RSS. Similar half part is connected through bus coupler. This make 100% standby arrangement in RSS.

POWER SUPPLY CHARACTERISTICS:

	220kV supply	**132kV supply**	**66kV supply**
Nominal Voltage	220kV	132kV	66kV
Maximum Voltage Variations	+ 10%, -15% of rated value	+ 10%, -15% of rated value	+ 10%, -15% of rated value
Nominal Frequency	50 Hz	50 Hz	50 Hz
Maximum frequency Variations	+ 3%	+ 3%	+ 3%
Short Circuit Current	40 A for 1 sec	22 A for 3 Sec	20 kA for 3 Sec.

Various equipment involved in RSS are given below:



1. Surge Arrester: Surge Arresters are used to protect outdoor electrical equipment from over voltages caused by external disturbances due to lightning and internal disturbances due to switching surges. Up to rated supply, it works as insulator with very high resistance. In case of voltage rise due to lightning or any types of surge, it works as conductor with low

resistance.

2. **Capacitive Voltage Transformer:** It is used to measure incoming voltage. Each incoming section and bus coupling section shall be equipped with voltage transformer on each phase.

3. **Current Transformer (CT):** This equipment converts high incoming current to low current signals for metering and protection purpose.

4. **Isolators:** Three pole isolator is designed for use in outdoor high voltage substation

5. **Post Insulators:** These types of insulator are used in high voltage substation for supporting bus bars.

6. **Circuit Breaker:** The circuit breaker is one of the most important electrical system. The protection, stability and continuity of the depends on the circuit breaker's ability to the switch line and to currents.

units in the system interrupt fault

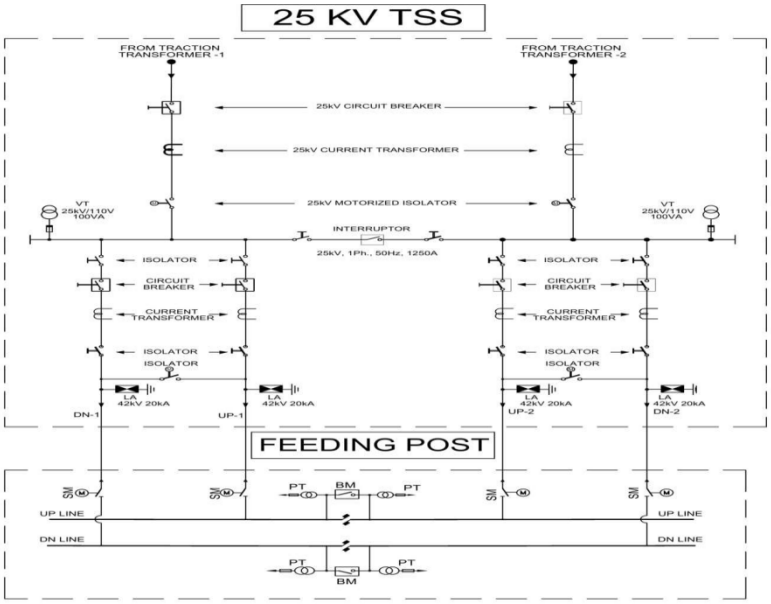
7. **Three Phase Auxiliary Transformer**: The capacity of the Three phase auxiliary transformer at 33kV is 220 / 33 kV, 132 / 33 kV, 66 / 33 kV.

8. **Traction Transformer:** The capacity of Traction

transformer at 25kV is 220/25 kV, 132 / 25 kV, 66 / 25 kV.

TRACTION SUBSTATION (TSS)

The TSS consist of feeders (generally four for mainline and one for depot traction supply) with adequate switching, metering and protection arrangements. Traction substations are used to convert electrical power as supplied by the power utility (or rail operators own network) to a form suitable for providing power to a rail system (via third rail or overhead line). Depending on the type of rail system this power would be either direct current (dc) or alternating current (ac). At each RSS, two single-phase transformers are installed, one of which is in service and the other is 100% standby. These transformers step down the grid voltage to 27.5 kV for feeding the traction overhead equipment (OHE). 25 kV feeders carry the power from the sub-stations to feeding posts located near the tracks.

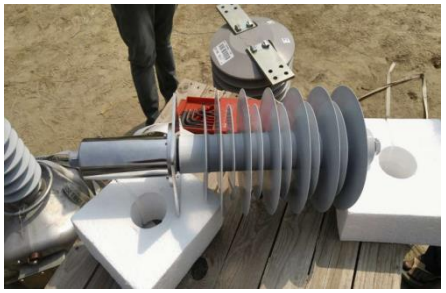


Traction Substation Equipment

1. Isolator : Isolators are switches which are used to make or brake the circuit. In the traction substation there are generally two types of isolators. At high voltages the use double pole isolators and at the lower level of voltages they use single pole isolators.

2. Current Transformer : The outdoor type 25kV current transformer (CT) is used for installation in 132/ 25kV Railway traction sub-station for operation of protective devices, metering and indication purpose. The current transformer is suitable for outdoor use and performs well in moist, tropical climate and in areas subject to heavy rainfall, pollution, marine atmosphere and severe lightening. Current Transformers are capable of withstanding heavy vibrations with rapidly varying time periods in the range of 15ms to 70ms and with amplitude in the range of 30 micron to 150 micron and instantaneous peak going up to 350 micron.

3. Potential Transformer : Also known as Instrument transformers are high accuracy class electrical devices used to isolate or transform voltage or current levels. The most common usage of instrument transformers is to operate instruments or metering from high voltage or high current circuits, safely isolating secondary control circuity from the high voltages or currents. The primary winding of the transformer is connected to the high voltage or high current circuit, and the meter or relay is connected to the secondary circuit.

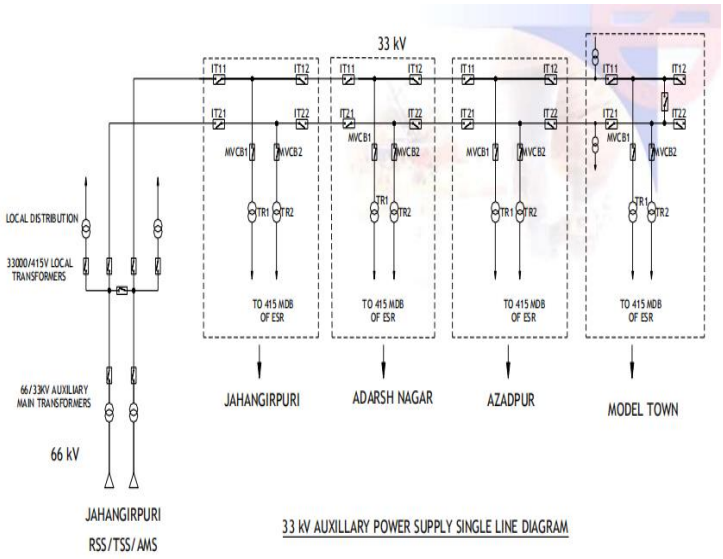


4. CVT : The capacitive voltage transformer step-down the high voltage input signals and provide the low voltage signals which can easily measure through the measuring instrument. For measuring high voltage (above 100kV) the high insulated transformer is required. The highly insulated transformer is quite expensive as compared to the normal transformer. For reducing the cost, the capacitive potential transformer is used in the system. The CVT is cheap, and their performance is not much inferior to the highly insulated transformer.

AUXILARY MAIN SUBSTATION (AMS)

It consists of two power transformers of 15/30/45 MVA capacity which transforms the incoming voltage into 33 kV and distributes the supply through 33 KV duplicate cable feeders to metro stations and backup supply for adjacent line. AMS Part of Substation is located in separate room adjacent to control room.

In electric power distribution, a busbar (also bus bar) is a metallic strip or bar, typically housed inside switch gear, panel boards, and busway enclosures for local high current power distribution.



An Overview of Phase – I,II & III

Line	RSS	Voltage Level (kV)
Line - 1	Kashmiri Gate	220
	Rithala	66
	Arthala	132
Line - 2	Jahangirpuri	220
	New Delhi	66
	Chattarpur	66
	Sushant Lok	66
Line - 3 & 4	Dwarka	66
	Subhash Nagar	66
	Indraprashta	66
	Botanical Garden	132
	Noida Sector 62	132
Line - 5	Mundka	66
	Bahadurgardh	132
Line - 6	Sarita Vihar	66
	Old Faridabad	66
	Kashmere Gate	220
	Park Street	66
	Mukundpur	66

Line - 7	Dhaula Kuan	66
	INA	66
	Vinod Nagar	66
	Yamuna Vihar	66
Line - 8	Kalkaji	66
	R.K. Puram	66
	Palam	66
Airport Line	Park Street	66
	Airport RSS	66

INTERLOCKING SCHEMES FOR AUX & TRACTION POWER SUPPLY

Protection Interlocks

Interlocks are used for protection of personnel and equipment due to inadvertent operations. An interlock is a feature that makes the state of two mechanisms or functions mutually dependent. It may be used to prevent undesired states in a finite-state machine. In most applications, an interlock is used to help prevent a machine from harming its operator or damaging itself by preventing one element from changing state due to the state of another element, and vice versa. Metros are equipped with an interlock that prevents the moving metro from opening its doors, and prevents the stationary metro (with open doors) from moving.

Types of Interlocks

1. Manual Interlocks
For example, Physical padlocks, although they have very limited usage in real life.

2. Mechanical Interlocks
Mechanical key interlocks shall be provided wherever applicable or as specified in BOQ and shall be so designed as to avoid mal-operation at the point of manual application. The scheme shall be such that attempts to remove a captive key shall not result in tripping or opening of the device. Interlocks may be strictly mechanical, as in one form of internal firearm safety, that blocks motion of the trigger, sear and/or firing pin unless the breech is properly closed & locked. In the operation of a device such as a press or cutter that is hand fed or the work piece hand removed, the use of two buttons to actuate the device, one for each hand, greatly reduces the possibility of operation endangering the operator.

3. Electrical Interlocks
Electrical interlocks on withdraw able equipment shall be so arranged that if the equipment is withdrawn, the complete operation of the withdrawn equipment shall be independent of the remote interlocking contacts. In addition, interlocks shall not be defeated leading to damages or unsafe operations of Electrical Panels due to the withdrawing of equipment. Many people use generators to supplement power to a home or business in the event that main (municipal) power has gone offline. In order to safely transfer the power source from a generator (and back to main), a safety interlock is often employed. The interlock consists of one or more switches that prevent both main power and generator power from powering the dwelling simultaneously.

Without this safeguard, both power sources running at once could cause an overload condition, or generator power back-feed onto the main could cause dangerous voltage to reach a lineman repairing the main feed far outside the building.

4. Programmable Interlocks
This is the simplest way of programming even complex interlocks. Extension/Modifications are

simple. Knowledge level to program the interlocking system is little high.

Interlock Used in DMRC

Series Interlocks, Parallel Interlocks, combination of both can be used in realizing Interlocks. Before closing/opening Isolators, CBs are to be opened. CBs cannot be closed if Earth switches are closed. CBs will trip and will not allow further closing if the insulating SF6 gas is low from the predefined values. Earth switches for adjacent stations mechanical locks 33KV/415V Transformer door interlock Mechanical / electrical Paralleling of two incoming transformers are forbidden. If an upstream CB trips, the down stream CB trips due to under voltage to prevent it not to charge the down stream CB when the power has resumed. Locking facilities shall be provided where appropriate for switches and isolators in order that they may be locked in the open position. Switch gear cubicle access doors shall be equipped with integral type locks, preferably incorporated in the handles of the equipment. 4.7.5 Where locking facilities are of the integral barrel type, the key for each lock shall be unique to the associated lock unless otherwise specified. 4.7.6 Two keys shall be provided for every lock supplied. The keys shall be fitted with rings with identification labels, and cabinets with glazed front- opening doors shall be provided. The cabinets shall be adequate in size and equipped with hooks to house all keys when not in use, and shall be mounted in positions to be decided.

CONCLUSION

The Delhi Metro planned in four phases is part of an Integrated Multi Mode Mass Rapid Transport System (MRTS) planned for dealing with the fast growing passenger traffic demand in Delhi. It provides an alternative safe and comfortable mode of transport by rail to a large fraction of passengers using the road transport in Delhi. It reduces the travel time of people using the metro.

Metro rail systems are superior to buses because they provide much higher carrying capacity, require only 1/5 th of the energy per passenger km compared to road-based systems, cause no air pollution, occupy no road space if underground and only about 2 metre width of the road if elevated. A metro system can carry the same amount of traffic as 7 lanes of bus traffic or 25 lanes of private motor cars and is more reliable, comfortable, safer than road-based systems and reduce journey time by anything between 50% and 75% depending on the road conditions.The Delhi Metro Rail Corporation’s success is attributed to an innovative company structure, a unique work culture, and organizational values reflected in a lean but effective organization, punctuality, professional competence, a quick decision-making process, and the sufficient delegation of powers.

REFERENCE

1. http://www.delhimetrorail.com/otherdocuments/SpecificationElectricall.pdf

2. http://delhigovt.nic.in/dmrc.asp

3. http://www.delhimetrorail.com

4. (2005a), Delhi Metro Rail Corporation, Environmental Impact Assessment for Phase IICorridors of Delhi Metro.

5. Murty, M. N. and B. N. Goldar (2006), Economic Evaluation of Investment Projects, Reportof Project Sponsored by Planning Commission, Government of India.